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Progeny Testing Longleaf Pine At Two Locations

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SUMMARY

Means for brown-spot infection and 3- and 8-year height growth were determined in progeny testing of 540 parents in two Gulfport, Mississippi, plantings and an Alexandria, Louisiana, planting, and of 60 of the parents at a subsequent Alexandria planting. To estimate growth at ages 5 and 8, both degree of brown-spot infection and height growth at age 2 were necessary independent variables, but for growth at age 8, 3rd-year height growth alone was sufficient. Families selected for rapid growth and brown-spot resistance in one location may not be the ones selected in another. Likewise, those selected in a brown-spot free area differed from those selected in an area where brown spot was prevalent. Implications for future breeding and seed orchard development are discussed.

Additional keywords: *Pinus palustris*, genotype x environment interaction, survival, growth, brown-spot needle blight.

IMPROVING BREEDING PROCEDURES

Longleaf pine (*Pinus palustris* Mill.) is recognized as a species with good wood, form, and growth potential. Natural regeneration techniques have been developed, and new plantations are being established. Through the use of genetically improved seed, increased planting success and production seem promising. In this study we determine what effect variation in infection by brown spot [*Scirrhia acicola* (Dearn.) Siggers] has relative to that of early height growth in predicting later growth, examine family x environment effects, and recommend genotypes for advanced generation breeding programs.

METHODS AND MATERIALS

Four open-pollinated progeny tests of the same natural growth parents were established—three in 1963 and one in 1969. The 1969 test was a retest of some parents included in the 1963 tests.

The 1963 tests included progeny from 540 parents selected from Louisiana, Mississippi, Alabama, Georgia, and Florida (Snyder and Derr 1972). Of these, 417 were from a Louisiana area known to have been severely infected with brown spot. One progeny test was established near Alexandria, Louisiana, and two near Gulfport, Mississippi. Each was laid out in a randomized, complete block design with 10 replications of single tree plots.

At Alexandria, trees were spaced 3 feet apart in furrows placed every 8 feet. Numerous infected volunteer seedlings between rows provided brown-spot inoculum. The two sites at Gulfport were disked a year before planting. At one site, disease spreader trees were established every 3 feet in rows 12 feet apart. A year later, test seedlings were planted in the same rows between each two disease spreader trees. At the other Gulfport site, test seedlings were planted at the same spacing but without disease spreader trees, and brown spot was controlled by spraying with Bordeaux mixture in May, June, and September. After three seasons in the field, the proportion of current needle tissue lost to brown spot in the three 1965 tests was estimated as a percentage of total needle tissue. Heights of all trees were measured at age 3 and those of some trees at age 8.

To test the goodness-of-fit for the family x location effects in the sprayed versus unsprayed plots at Gulfport, we used a chi-square procedure. Values corresponding to probabilities of less than 0.05 were considered significant. To determine the importance of early growth and brown-spot incidence as predictors of later growth (Draper and Smith 1966), we used stepwise regressions on individual trees.

To follow-up the 1963 brown-spot test, we established a fourth test at Alexandria in 1969, using newly collected seed from 60 parents randomly selected from the original 540. Added to these as resistant, wind-pollinated controls were two Alexandria families, Abe and 1.1E, that displayed good early growth in previous tests (Derr 1963). A susceptible Alexandria family, PR, was also included. (Abe x W) x W was entered to determine the effects of backcrossing. Spring-sown seedlings were lifted in the fall, transplanted to 1-quart milk cartons, and planted in the spring.

The 1969 test site was open and devoid of natural seedlings, but brown-spot infection was heavy in an adjacent longleaf plantation. The area was burned, then furrowed with a fireplow. Seedlings were planted in the furrow at 6 x 6 foot spacing in a randomized, complete block design with four replications of 10-tree row plots. At age 2, the proportion of current needle tissue lost to brown spot was estimated as it was for the 1963 tests. At ages 2 and 5, the heights of all trees were measured. In summary, the four experiments were: 1963 brown-spot test at Alexandria, 1963 brown-spot test at Gulfport, 1963 sprayed test at Gulfport, and the 1969 brown-spot follow-up test at Alexandria.

RESULTS

Early prediction

Brown-spot infection and 3- and 8-year height means for the four experiments are given in table 1. For each of 202 random individuals in the 1963 brown-spot test at Gulfport and 154 in the one at Alexandria, individual and family means for 3-year-old height and brown-spot damage were entered into stepwise regressions to determine their contributions to the 8-year height variation. Numbers of trees chosen were proportional to survivals at the two locations. With only 3-year individual growth included, R^2 values were 0.52 and 0.46 for Gulfport and Alexandria, respectively. Inclusion of any combination of the other three traits did not change the R^2 values by more than 0.01. Thus, for practical purposes, selections at age 3 could be based solely on an individual's height—additional variables explain little of the 8-year height variation.

Table 1.—*Mean brown spot and height*

Test	Brown spot[1]	Early height[2]	Later height[3]
	Percent	*Inches*	*Feet*
1963 brown-spot test at Alexandria, La.	55	3.0	16.5
1963 brown-spot test at Gulfport, Ms.	71	6.4	19.1
1963 sprayed test at Gulfport, Ms.	0	23.6	23.2
1969 brown-spot test at Alexandria, La.	49	5.3	7.2

[1] Percentage of needle tissue killed at age 3 (1963 tests) or age 2 (1969 test).
[2] Heights at 3 years (1963 tests) or 2 years (1969 test).
[3] Heights at 8 years (1963 tests) or 5 years (1969 test).

The 1969 test was used to relate 2nd-year growth and brown spot to 5th-year growth. When considered together variation in height and brown spot at age 2 explained 71 percent of the variation in 5-year heights. With only 2-year heights or only brown spot in the equation, $R^2 = 0.36$. This correlation indicates that, unlike the test above, the predictive index requires both 2-year height and brown-spot resistance. Thus, the use of brown-spot damage as a selection criterion in these tests depended on age of trees at time of selection.

Roguing a progeny test may be necessary before trees are mature, particularly if the test is to be converted into a seedling orchard. The breeder should be aware that selection criteria may change with time. Roguing for brown-spot susceptibility could start in the greenhouse as early as 6 months of age, and badly diseased families could be eliminated from subsequent expensive field tests (Kais 1975). A similar

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roguing for brown-spot susceptibility could be performed after one season in the field.

Since only a few families began height growth during the 2nd year, there was only minimal opportunity for brown spot to have an impact on height growth. Consequently, at age 2 both brown spot and height were needed in a predictive index. By age 3, height growth alone becomes a satisfactory predictor of 8-year growth since damage from brown spot is almost completely translated into decreased height growth.

Comparison of family performances in two tests at one location

Results of the two brown-spot tests at Alexandria show that a single preliminary selection test is not necessarily the best solution. The correlation between family means for age 3 heights in the 1963 test with age 5 heights of the 1969 test was 0.31. If the best 30 percent were selected on the basis of age 3 heights, the 1969 average of the selected trees would be 7.6 feet versus an average of 6.7 feet for the worst 30 percent. Four families, or two-thirds of the best six 1969 performers would have been isolated. To illustrate the types of relationships found, we contrasted mean heights of families performing best and worst in 1969 with their 1963 performance (table 2). Wind-pollinated families of Abe, 1.1E, and PR, which had been tested in former Alexandria tests but not represented in the 1963 tests, performed as expected in the 1969 test. Also as expected, the growth potential of Abe was reduced by the backcrossing effects of wind pollination in the progeny of (Abe x W) x W.

Table 2.—*Mean heights of fastest and slowest growing families in the 1969 brown-spot test at Alexandria compared to their mean heights in the 1963 brown-spot test*

Family	1963 test 3-year ht.	1969 test 5-year ht.
	Inches	*Feet*
Fast growing		
168	13.5	10.4
306	2.1	10.4
98	5.6	9.4
163	3.4	9.3
216	2.0	9.2
61	6.0	9.1
1.1E	—	8.6
Abe x W	—	7.9
Slow growing		
(Abe x W) x W	—	5.4
301	2.2	5.4
433	2.0	5.2
145	1.9	5.2
396	1.6	5.2
395	1.6	4.6
202	3.4	3.6
PR	—	2.6
General Mean	*3.0*	*7.2*

The lack of high correlation between the 1963 and the 1969 tests is not too surprising. The test material was from a different seed year and perhaps had some different pollen parents. The earlier test was planted in a more severe brown-spot infection year (55 versus 40 percent). Yearly variation in weather may have influenced establishment. Thus, it seems appropriate to use results from several progeny tests where they are available.

Comparison of family performances at two locations

Although 3-year data from the 540 trees of the 1963 study showed a significant family x location interaction, earlier speculation was that the best families for breeding could be selected from combined data. The following results, however, suggest the need to conduct progeny tests in the area where the seed is to be used.

Using 3rd-year data of the 1963 test, we ranked the top 5 percent of the 540 families adapted to Gulfport and, similarly, the top 5 percent adapted to Alexandria. The 17 families selected only for Gulfport were, on the average, in the 42nd percentile in the 1963 Alexandria test (table 3). The 22 families selected only for Alexandria were in the 40th percentile in the 1963 Gulfport test. The 1969 Alexandria test generally supports the 1963 rankings at Alexandria and supports the suggestion that single location results such as those at Alexandria may not be adequate for selection for broad geographic areas.

If we limit families selected to those in the upper 10 percent in the two 1963 brown-spot plantings, eight families (1.5 percent) appear to be generally adapted (last columns, table 3). Several more are included on the basis of the 1969 test. The scarcity of generally adapted types indicates the need for supplementing them with a breeding procedure using more specifically adapted types. Using generally adapted types would permit interchange of material over large sections of the range, but to obtain gains equal to those for specifically adapted types, the selection and testing program necessarily would have to be large. We believe that breeding the best specifically adapted 5 percent and the best generally adapted 10 percent is realistic. Control pollinations are in progress, and progeny tests will reveal which of

Table 3.—*Percentile rankings in three brown-spot tests of heights for families adapted to Gulfport, Alexandria, and both locations*

Family	Adapted to Gulfport Only: Gulfport 1963	Alex 1963	Alex 1969	Family	Adapted to Alexandria Only: Gulfport 1963	Alex 1963	Alex 1969	Family	Adapted to Both Locations: Gulfport 1963	Alex 1963	Alex 1969
142	1	28	—	101	81	1	—	168	1	1	1
301	1	57	86	190	77	1	—	435	1	4	—
366	1	30	—	199	23	1	—	446	4	1	—
119	2	50	22	449	22	1	—	216	1	—	5
198	2	63	—	20	28	1	79	239	2	6	—
215	2	53	64	313	50	2	—	269	8	2	—
360	2	32	—	519	47	2	—	258	1	10	—
77	3	21	21	525	15	2	—	163	3	20	2
267	3	53	—	15	78	3	—	65	1	20	6
296	3	48	—	78	29	3	—	471	4	11	—
108	4	22	—	140	22	3	—	194	8	9	—
118	4	42	—	386	26	3	—	230	7	2	26
290	4	39	58	464	44	3	—	214	7	12	20
302	4	31	—	503	72	3	—	62	3	33	10
75	5	43	—	113	47	4	—				
241	5	76	—	123	19	4	—				
429	5	20	38	390	48	4	—				
				538	14	4	—				
				71	28	4	—				
				61	54	5	14				
				265	38	5	—				
				451	23	5	—				
				Abe	—	—	12				
				1.1E	—	—	16				
Average Percentile	*3*	*42*	—		*40*	*3*	—		*4*	*10*	*10*

those tested have sufficiently high breeding values for inclusion in second generation orchards. Meanwhile, parents that have so far produced good progeny will be available shortly for inclusion in first generation orchards.

Comparison of family performance with and without the presence of brown spot

Poor correspondence between family height growth in diseased and disease-free tests has been reported (Snyder and Derr 1972). This finding is now supported by the 8-year growth in the two Gulfport tests—one with and one without brown-spot control. Of the 540 parents, only 12 percent originated east of Louisiana. Yet, after 8 years in plots where brown spot was controlled, eight of the 25 tallest families (32 percent) were from the eastern source. That is, in sprayed plots, eastern sources were three times as effective in providing good performers. In the adjacent infected plots, none of the top 25 was of eastern origin—a significant difference according to chi-square tests. This suggests that selecting trees from western origins (west of Florida panhandle where there are greater selection pressures for resistance to brown spot) would not be efficient for eastern areas where brown spot is not severe. If this is confirmed by tests now in progress, still greater emphasis will have to be placed on geographic areas for selection and progeny testing if the improvement programs are to be most effective.

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